COMPUTATIONAL MODELING TO LIMIT THE IMPACT DISPLAYS AND INDICATOR LIGHTS HAVE ON HABITABLE VOLUME OPERATIONAL LIGHTING CONSTRAINTS

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NASA has demonstrated an interest in improving astronaut health and performance through the installment of a new lighting countermeasure on the International Space Station. The Solid State Lighting Assembly (SSLA) system is designed to positively influence astronaut health by providing a daily change to light spectrum to improve circadian entrainment. Unfortunately, existing NASA standards and requirements define ambient light level requirements for crew sleep and other tasks, yet the number of light-emitting diode (LED) indicators and displays within a habitable volume is currently uncontrolled. Because each of these light sources has its own unique spectral properties, the additive lighting environment ends up becoming something different from what was planned or researched. Restricting the use of displays and indicators is not a solution because these systems provide beneficial feedback to the crew.

The research team for this grant used computer-based computational modeling and real-world lighting mockups to document the impact that light sources other than the ambient lighting system contribute to the ambient spectral lighting environment. In particular, the team was focused on understanding the impacts of long-term tasks located in front of avionics or computer displays. The team also wanted to understand options for mitigating the changes to the ambient light spectrum in the interest of maintaining the performance of a lighting countermeasure. The project utilized a variety of physical and computer-based simulations to determine direct relationships between system implementation and light spectrum.

Using real-world data, computer models were built in the commercially available optics analysis software Zemax Optics Studio©. The team also built a mockup test facility that had the same volume and configuration as one of the Zemax models. The team collected over 1200 spectral irradiance measurements, each representing a different configuration of the mockup. Analysis of the data showed a measurable impact on ambient light spectrum. This data showed that obvious design techniques exist that can be used to bind the ambient light spectrum closer to the planned spectral operating environment for the observer's eye point.

The following observations should be considered when designing an operational environment that is dominated by computer displays. When more light is directed into the field of view of the observer, the greater the impact it will make on various human factors issues that depend on spectral shape and intensity. Because viewing angle has a large part to play in the amount of light flux on the crewmember's retina, beam shape, combined with light source location is an important factor for determining percent probable incident flux on the observer from any combination of light sources. Computer graphics design and display lumen output are major factors influencing the amount of spectrally intense light projected into the environment and in the viewer's direction. Use of adjustable white point display software was useful only if the predominant background color was white and if it matched the ambient light system's color. Display graphics that used a predominantly black background had the least influence on unplanned spectral energy projected into the environment. Percent reflectance makes a difference in total energy reflected back into an environment, and within certain architectural geometries, reflectance can be used to control the amount of a light spectrum that is allowed to perpetuate in the environment. Data showed that room volume and distance from significant light sources influence the total spectrum in a room. Smaller environments had a homogenizing effect on total light spectrum, whereas light from multiple sources in larger environments was less mixed.

The findings indicated above should be considered when making recommendations for practice or standards for architectural systems. The ambient lighting system, surface reflectance, and display and indicator implementation all factor into the users' spectral environment. A variety of low-cost solutions exist to mitigate the impact of light from non-architectural lighting systems, and much potential for system automation and integration of display systems with the ambient environment. This team believes that proper planning can be used to avoid integration problems and also believes that human-in-the-loop evaluations, real-world test and measurement, and computer modeling can be used to determine how changes to a process, display graphics, and architecture will help maintain the planned spectral operating lighting environment. Supported by NASA Grant #14-14Omni2-0018, NRA# NNJ14ZSA001N.